



King's Research Portal

DOI:

[10.1016/j.mhpa.2016.09.002](https://doi.org/10.1016/j.mhpa.2016.09.002)

Document Version

Peer reviewed version

[Link to publication record in King's Research Portal](#)

Citation for published version (APA):

Vancampfort, D., Firth, J., Schuch, F. B., Rosenbaum, S., Probst, M., Ward, P. B., Van Damme, T., De Hert, M., & Stubbs, B. (2016). Dropout from physical activity interventions in children and adolescents with attention deficit hyperactivity disorder: A systematic review and meta-analysis. *Mental Health and Physical Activity*. <https://doi.org/10.1016/j.mhpa.2016.09.002>

Citing this paper

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

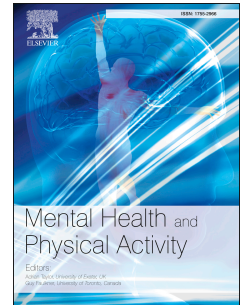
Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Accepted Manuscript

Dropout from physical activity interventions in children and adolescents with attention deficit hyperactivity disorder: A systematic review and meta-analysis

Davy Vancampfort, Joseph Firth, Felipe B. Schuch, Simon Rosenbaum, Michel Probst, Philip B. Ward, Tine Van Damme, Marc De Hert, Brendon Stubbs



PII: S1755-2966(16)30042-4

DOI: [10.1016/j.mhpa.2016.09.002](https://doi.org/10.1016/j.mhpa.2016.09.002)

Reference: MHPA 189

To appear in: *Mental Health and Physical Activity*

Received Date: 27 June 2016

Revised Date: 20 August 2016

Accepted Date: 27 September 2016

Please cite this article as: Vancampfort, D., Firth, J., Schuch, F.B., Rosenbaum, S., Probst, M., Ward, P.B., Van Damme, T., De Hert, M., Stubbs, B., Dropout from physical activity interventions in children and adolescents with attention deficit hyperactivity disorder: A systematic review and meta-analysis, *Mental Health and Physical Activity* (2016), doi: 10.1016/j.mhpa.2016.09.002.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Mental Health and Physical Activity**Dropout from physical activity interventions in children and adolescents with attention deficit hyperactivity disorder: a systematic review and meta-analysis**

Davy Vancampfort^{a,b}, Joseph Firth^c, Felipe B. Schuch^d, Simon Rosenbaum^e, Michel Probst^a, Philip B. Ward^{f,g}, Tine Van Damme^a, Marc De Hert^b, Brendon Stubbs^{h,i}

^aKU Leuven – University of Leuven, Department of Rehabilitation Sciences, Leuven, Belgium

^bKU Leuven – University of Leuven, University Psychiatric Center KU Leuven, Leuven-Kortenberg, Belgium

^cInstitute of Brain, Behaviour and Mental Health, University of Manchester, Manchester, UK

^dHospital de Clínicas de Porto Alegre, Porto Alegre, Brazil

^eDepartment of Exercise Physiology, School of Medical Sciences, University of New South Wales, Sydney, Australia

^fSchool of Psychiatry, University of New South Wales, Sydney, Australia

^gSchizophrenia Research Unit, South Western Sydney Local Health District, Ingham Institute of Applied Medical Research, Liverpool, Australia

^hPhysiotherapy Department, South London and Maudsley NHS Foundation Trust, London, UK

ⁱHealth Service and Population Research Department, Institute of Psychiatry, Psychology and Neuroscience (IoPPN), King's College London, De Crespigny Park, London, UK

Running title: ADHD and physical activity

Acknowledgments: None to report.

Funding: Davy Vancampfort is funded by the Research Foundation – Flanders (FWO-Vlaanderen). Brendon Stubbs receives funding from the National Institute for Health Research Collaboration for Leadership in Applied Health Research & Care Funding scheme. Simon Rosenbaum is funded by a Society For Mental Health Research Early Career Fellowship. The views expressed in this publication are those of the authors and not necessarily those of the funding agencies.

*Corresponding author: Davy Vancampfort. KU Leuven – University of Leuven, University Psychiatric Center KU Leuven, campus Kortenberg, Leuvensesteenweg 517, 3070 Kortenberg, Belgium; Tel.: +32 2 758 05 11; Fax: +32 2 759 9879. E-mail address: davy.vancampfort@uc-kortenberg.be

Abstract

Physical activity (PA) interventions have shown promising in improving core symptoms of children and adolescents with ADHD, yet treatment dropout may pose a challenge to routine implementation in clinical practice. We conducted a meta-analysis to investigate the prevalence and predictors of treatment dropout from PA interventions in children and adolescents with ADHD. Electronic databases were searched from inception until 06/2016. Randomized control trials of PA interventions in children and adolescents with ADHD reporting dropout rates were included. A random effects meta-analysis and meta-regression analyses were performed. In 8 studies involving 9 PA intervention arms, 148 children or adolescents assigned to a PA intervention (mean age range=8.2 to 15.8 years, 87.8% male) were included. The trim and fill adjusted treatment dropout rate was 17.5% (95%CI=9.8% to 29.4%). The prevalence of dropouts in exercisers was not significantly different from the dropouts in control conditions (odds ratio, OR=1.12; 95%CI=0.48-2.65; $I^2=0$). Lower dropout was observed in sports interventions compared with structured aerobic exercise or yoga ($p=0.049$). A higher proportion of male participants ($\beta=0.05$; 95%CI=0.001 to 0.10; $p=0.045$, $R^2=1.0$) appeared to moderate higher dropout rates from PA interventions. Our findings suggest that in order to maximize PA participation, and therefore health benefits, sports-related interventions should be offered in the multidisciplinary treatment of children and adolescents with ADHD. Our data also suggest that males with ADHD may be more likely to dropout. Dropout rates are comparable to control conditions, suggesting that PA interventions are feasible in adolescents with ADHD.

Keywords: ADHD; attention; hyperactivity; physical activity; exercise

Attention deficit hyperactivity disorder (ADHD) is a childhood-onset neurodevelopmental disorder characterised by inattention, motor hyperactivity and impulsivity, with problems often continuing into adulthood (Thapar & Cooper, 2016). The estimated prevalence of ADHD in children is 3 to 4% (Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015). Currently, treatment of ADHD frequently relies on pharmacotherapy, with stimulants such as methylphenidate and dexamphetamine constituting the first-line and the noradrenaline reuptake inhibitor atomoxetine the second-line treatment (Chan, Fogler, & Hammerness, 2016). Pharmacotherapy is associated with side-effects, including appetite suppression, gastrointestinal symptoms, insomnia, tics and even more severe adverse effects such as cardiac problems and growth retardation (Thapar & Cooper, 2016). Pharmacological treatment should be used in conjunction with behavioural interventions such as classroom management strategies, parental psycho-education, and behavioural management techniques, although these interventions have inconsistent effects on ADHD symptoms (Chan, Fogler, & Hammerness, 2016).

Recently, interest has grown in physical activity and exercise as potential interventions for the multidisciplinary treatment of adolescents with ADHD. There is some evidence to suggest that acute aerobic exercise has beneficial effects on various executive functions (e.g., impulsivity), and that regular aerobic training may also confer chronic benefits for executive functions, attention and behavior (Den Heijer, et al., 2016). Preliminary research has further indicated that non-aerobic exercise, such as yoga, may also be associated with both acute and chronic improvements in the core symptoms of ADHD, although again the efficacy has yet to be fully established (Jensen & Kenny, 2004).

Whilst physical activity interventions offer promise among children and adolescents with ADHD, participant dropout can impede real-world implementation of interventions. Children and adolescents who drop out may also experience worse clinical outcomes (Boggs, et al., 2005). At societal level, dropout and lack of adherence to treatment are of major concern for budget holders and policy makers as it is associated with greater risk of (re)hospitalization, and greater resource utilization (Osterberg & Blaschke, 2005).

From a research perspective, participants who fail to complete study protocols can affect statistical analyses, research outcomes, and interpretation of results. For example, the current

research evidence for physical activity interventions in children and adolescents with ADHD is mainly based on data from participants completing the interventions. This may skew results, favoring those who fully engage with physical activity. Some features common to randomized controlled trials (RCTs) investigating physical activity interventions in ADHD, such as the use of pre-determined manualized protocols (e.g., in terms of frequency, intensity, time, type) and specific eligibility criteria (e.g., inclusion of children and adolescents without psychiatric or physical co-morbidities) have the potential to affect dropout rates. This suggests the need to consider dropout from RCTs in vulnerable populations separately from pragmatic or real-world interventions (Stubbs, et al., 2016; Vancampfort, et al., 2016).

Clearly, understanding and quantifying the prevalence and predictors of dropouts in physical activity interventions in children and adolescents with ADHD would help to improve the design of new studies, in addition to informing clinical practice and policy. To date, no meta-analysis has examined the prevalence and predictors of dropout from physical activity RCTs in this population. The current meta-analysis therefore had the following aims: (i) To establish the prevalence of dropout in physical activity RCTs among children and adolescents with ADHD. (ii) To compare the prevalence of dropout from physical activity with the dropout in non-active control conditions. (iii) To identify predictors that may influence dropout and adherence such as demographic (e.g., mean age, % male), illness-related variables (e.g., illness duration, % psychiatric co-morbidity), physical activity intervention parameters (e.g. frequency, intensity, time and type of physical activity intervention) and treatment-related factors (e.g. the professional qualifications of the person delivering the intervention).

1. Methods

This systematic review was conducted in accordance with the MOOSE guidelines (Stroup, et al., 2000).

1.1. Eligibility criteria

Included in this meta-analysis were RCTs that: (a) Included children or adolescents age 6 to 18 years with a formal DSM (American Psychiatric Association, 2013; Association, 1994) or ICD (Organization, 1993) diagnosis of ADHD. Studies including mixed samples were only eligible if greater than 80% of the sample had a diagnosis of ADHD. (b) Investigated physical activity interventions with a minimum duration of 2 weeks. Physical activity was defined, in accordance with Caspersen, Powell, and Christenson (1985), as any interventions that used bodily movement produced by skeletal muscles and which required energy expenditure. Exercise interventions were defined as physical activity that is planned, structured, repetitive and purposive in the sense that improvement or maintenance of physical fitness or health was an objective. Interventions only including counseling to increase physical activity levels were excluded. (c) Provided information on dropout rates. (d) Were published in an international peer reviewed journal. Multiple physical activity conditions within a single RCT were included in the analyses, so long as individuals only participated in one active arm of the trial. We considered any type of physical activity meeting the above criteria. For studies reporting follow-up assessments, we focused on the active phase of the condition, as defined by the authors of each publication. Excluded were multimodal interventions where the co-interventions were not also delivered to the control participants.

1.2. Information sources and searches

Two independent reviewers (DV, BS) searched Embase (major focus), PsycARTICLES, and Medline without language restrictions from database inception until June 15th, 2016, using the key words 'ADHD' OR 'attention deficit' OR 'hyperactivity' AND 'exercise' OR 'physical activity' OR 'sports'. In addition, reference lists of all eligible articles and most recent systematic reviews were screened to identify additional studies.

1.3. Study selection

After removal of duplicates, two independent reviewers screened the titles and abstracts of all potentially eligible articles. Two authors applied the eligibility criteria, and a list of full text articles was developed through consensus. Two authors (DV, BS) considered the full texts of included articles and a final list of included articles was reached through consensus.

1.4. Outcomes

The primary outcome was the treatment dropout rate in physical activity interventions in children or adolescents with ADHD. We adopted a definition of dropout consistent with its typical use in RCTs, and that adopted in other reviews of dropout in physical activity RCTs (Vancampfort et al 2016, Stubbs et al 2016), which was: 'unexpected patient attrition among individuals who were randomized to a treatment but failed to complete it' (Cooper & Conklin, 2015). This definition included any child or adolescents who would be included in intent-to-treat (ITT) analyses, such as those who refused their randomization, never /seldom attended a session, stopped attending sessions, or withdrew consent before completing the designated treatment. Patients who were lost prior to randomization were not considered dropouts. Additionally, administrative removals of study patients and instances of data loss were not treated as dropouts. For comparison purposes, we also collected overall dropout rates in all non-active control conditions (e.g., wait list conditions, treatment as usual).

1.5. Data extraction

Two authors (DV, BS) extracted data using a data extraction form. In this extraction form we divided moderators of the extracted dropout rates broadly into three domains: provider variables, exerciser/participant variables, and design/implementation variables. For the provider variables, expertise was coded as (i) experts in moderate to high intensity exercise prescription or (ii) no experts / no qualification / no information provided. Providers of physical activity/exercise interventions were considered experts when they had at a minimum a bachelor-level degree in physical therapy / physiotherapy, sports therapy, exercise physiology or a similar qualification that included education in exercise prescription and assessment. Cardiologists and sports physicians were also considered as experts. Exerciser/participant variables included mean age, % male, mean duration of illness, mean

baseline body mass index, and % psychiatric co-morbidity. Design/implementation variables included type (structured aerobic exercise vs. yoga vs. sports), frequency (number of sessions per week), intensity level (low, moderate, moderate to high, as defined by the American College of Sports Medicine (ACSM's Guidelines for Exercise Testing and Prescription. V, 2009) and mean duration (in minutes) of the last session, supervision during the entire study period (yes or no / not reported), multimodality (yes or no; yes= inclusion of co-interventions other than usual care), the addition of motivational elements to the intervention (yes or no / not reported), and the setting in which the physical activity intervention took place (inpatient, outpatient, or community settings).

1.6. Meta-analysis

We conducted a random effects meta-analysis with Comprehensive Meta-Analysis software (CMA, Version 3). First, we calculated the prevalence of drop-out together with the 95% confidence interval (CI). Second, we conducted meta-regression and subgroup analyses with CMA to investigate the potential moderators. The significance level was set at $p < 0.05$. Heterogeneity was assessed with the I^2 statistics for each analysis with a value $> 50\%$ considered as substantial heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003). Publication bias was assessed with the Begg and Mazumdar rank correlation test (Kendall's tau) (Begg & Mazumdar, 1994) and the Egger bias test (Egger, Smith, Schneider, & Minder, 1997) ($p < 0.05$). Moreover, for the main composite analyses, we conducted a trim and fill adjusted analyses (Duval & Tweedie, 2000) to remove the most extreme small studies from the positive side of the funnel plot, and recalculated the pooled drop-out prevalence at each iteration, until the funnel plot was symmetric about the (new) pooled drop-out prevalence.

2. Results

2.1. Study selection

The initial search yielded 6,273 hits. After removal of duplicates and irrelevant papers, 62 abstracts and titles were screened. At the full text review stage, 14 articles were considered and 6 were subsequently excluded (see Figure 1 for search results). Overall, 8 unique studies (Bustamante, et al., 2016; Chang, Hung, Huang, Hatfield, & Hung, 2014; Choi, Han, Kang, Jung, & Renshaw, 2015; Janssen, et al., 2016; Jensen & Kenny, 2004; Kang, Choi, Kang, & Han, 2011; Lee, Lee, & Park, 2015; Meßler, Holmberg, & Sperlich, 2016) were included in the meta-analysis. One study included two physical activity arms. Therefore, a total of 9 physical activity intervention arms were included. Full details of the included studies are summarized in Table 1.

Insert Figure 1 about here

2.2. Study, participants and providers' characteristics

Across the 8 unique studies and 9 intervention arms there were 148 children or adolescents assigned to a physical activity intervention (mean age range= 8.2 to 15.8 years, 87.8% male). A range of physical activity interventions was included; aerobic exercise (n=4), sports therapy (n=4) and yoga (n=1). The duration of the physical activity interventions ranged from 3 to 20 weeks, the frequency from one to five times per week, and the time per session from 30 to 90 minutes. Only 2 interventions included qualified professionals (i.e. providers of exercise intervention were physical therapists, exercise physiologists or those with a similar qualification including education in exercise prescription and assessment) while 8 intervention arms were supervised for the entire study period. Three studies added a motivational component in their intervention (i.e., emphasis on enjoyment, rewards). Further details of the included studies are summarized in Table 1.

Insert Table 1 about here

2.3. Meta-analysis of dropout rates in physical activity RCTs

The pooled physical activity dropout rate across 8 unique studies including 9 physical activity arms in children or adolescents with ADHD was 12.6% (95%CI=6.8% to 22.0%, $p<0.001$, $I^2=26.1$; Kendall's tau=-0.43, $z=1.56$, $p=0.12$; Egger=-2.24, $p=0.046$). Due to publication bias, we calculated a trim and fill adjusted prevalence, which was 17.5% (95%CI=9.8% to 29.4%, adjusted studies=4).

2.4. Comparative meta-analysis of dropout rates in physical activity versus control groups

The pooled dropout in the non-active control condition was 12.1% (95%CI=7.0% to 20.1%, $p<0.001$, $I^2=14.4$; Begg=-0.14, $p=0.65$; Egger=-0.38, $p=0.38$). The trim and fill adjusted prevalence was 13.1% (95%CI=8.0% to 20.9%, adjusted studies=2). The prevalence of dropouts in the physical activity interventions was not significantly different from the dropouts in control groups with a trim and fill adjusted odds ratio (OR) of 1.12 (95% CI=0.48 to 2.65; $I^2=0$).

2.5. Subgroup analyses investigating dropout rates in physical activity RCTs

Our meta-analysis shows that no significant differences in dropout scores were found between different settings (i.e. inpatients versus outpatients versus community patients) ($p=0.92$), between supervised versus not always supervised interventions ($p=0.36$), between qualified and non-qualified providers ($p=0.14$), in studies adding versus not adding a motivational component ($p=0.10$), in unimodal versus multimodal studies ($p=0.68$), between different physical activity frequencies (i.e. 2 versus 3 versus 5 times per week) ($p=0.41$), and between different physical activity intensities (i.e. low versus moderate versus high) ($p=0.79$). In contrast, lower dropout was observed in sports interventions compared with structured aerobic exercise or yoga ($p=0.049$). Details of all different subgroup analyses can be found in Table 2.

Insert Table 2 about here

2.6. Meta-regressions investigating moderators of the dropout rates in physical activity RCTs

Separate single meta-regression analyses revealed that dropout rates were not moderated by age and by intervention characteristics such as time of a single intervention (expressed in minutes) and duration of the entire physical activity intervention (expressed in weeks). The only exerciser/participant variable that moderated lower dropout rates was male gender (expressed as % male). Details of all meta-regressions are summarized in Table 3.

Insert Table 3 about here

3. Discussion

3.1. General findings

The current meta-analysis is the first to systematically evaluate dropout rates and predictors for physical activity interventions in children or adolescents with ADHD. Our meta-analysis demonstrated that 17.5% (95%CI=9.8% to 29.4%) of the children or adolescents with ADHD assigned to physical activity arms of RCTs dropped out. The finding that physical activity results in similar dropout rates compared to control conditions is important and suggests that physical activity is at least as feasible, accepted and tolerated as care as usual or other non-active conditions by children or adolescents with ADHD. Given the fact that physical activity is promising in improving core symptoms such as attention, hyperactivity and impulsivity (Den Heijer, et al., 2016), our results support the feasibility of physical activity interventions in children or adolescents with ADHD.

It might be expected that due to core symptoms such as inattention and impulsivity, children and adolescents with ADHD encounter more difficulties in adhering to physical activity programs. For example, an examination of physical activity participation rates in early elementary school children revealed that children at risk for ADHD (n=94) have significantly lower rates of participation as compared with their typically developing counterparts (n=108) (participation rate = 76% versus 89%) (Hoza, et al., 2015). The observation in our meta-analysis that almost 1 in 5 children or adolescents with ADHD assigned to physical activity drop out, points to the need for additional resources to deal with dropout from physical activity interventions.

Our results provide an indication of how these resources may be most effectively directed. Of the physical activity intervention characteristics, supervision throughout the study period, the qualification of the physical activity provider, and the frequency, intensity and time of the physical activity intervention did not influence dropout rates. The fact that adding a motivational component to the intervention and qualification of the professionals did not explain lower dropout rates is probably due to the lack of data (N=3 and N=2 respectively); such strategies are often part of routine clinical

practice and are not reported. Adding a motivational component may reduce attrition, as drop-outs from these interventions were lower (5.4% vs 16.3%), with a trend towards statistical significance ($p=0.10$). The paucity of research focusing on additional motivation components indicates that more work is needed as to how children or adolescents with ADHD can be motivated towards what kind of physical activity and by whom. Our meta-analysis offers some indications as it shows that lower dropout was observed in sports and play therapy sessions (5%) versus structured aerobic exercise (16.7%) and yoga (25%). Future research should explore which characteristics of sports therapy (e.g., focus on group interactions and cohesion, diversity of the physical activities offered) make the interventions attractive for children or adolescents with ADHD. While previous research (Yazdani, 2013) already indicated that the main barriers to physical activity reported by parents were a child's lack of interest (43%), lack of developmentally appropriate programs (33%), too many behavioural problems (32%), and parents' lack of time (29%), research on the preferences and barriers reported by children and adolescents with ADHD themselves is currently unavailable. Such information would assist in improving current treatment programs, by exploring whether maximizing opportunities for personal decision making, while providing resources and support (how much and which) needed to enhance feelings of competence and social relatedness (which are considered basic psychological needs as stipulated by the self-determination theory (Deci & Ryan, 2000)) result in long-term behavior change and lower dropout rates. Previous research in classroom settings indicated that these strategies may be particularly beneficial for those with ADHD symptoms in the classroom as the presence of ADHD symptoms may interfere with the fulfilment of basic psychological needs (Rogers & Tannock, 2013).

The fact that male gender is the only demographical variable that predicts a higher dropout rate warrants further exploration. One potential hypothesis is that young males might have higher ratings of hyperactivity, inattention, impulsivity, and externalizing problems (Gershon & Gershon, 2002), reinforcing the need to explore the most optimal motivational strategies to deal with these core ADHD symptoms.

3.2. Limitations and future research

We have to acknowledge several limitations that are inherent to the RCT literature and meta-analytic research in general. These include the inability to draw conclusions about specific reasons of

children and adolescents with ADHD for dropout, and under-reporting of potentially valuable information regarding patient and study characteristics (e.g., mental and physical co-morbidities, body mass index, illness duration). Information regarding some of the potential moderators were only provided by a small number of studies, which may impact detection of effects through meta-regression analyses. Additionally, meta-regression techniques are only able to detect whether a variable is associated with dropout across studies. None of the included studies provided sufficient detailed information on characteristics of dropouts versus completers in order to conduct separate comparative analyses of predictor variables. It is evident that future research will be enhanced by improved consistency in reporting of differences between completers and non-completers. Future large-scale systematic reviews and meta-analyses at patient-level might also assist in a more thorough identification of demographical (e.g., ethnicity and socio-economic status) and clinical (e.g. severity of clinical symptoms such as hyperactivity, inattention, impulsivity, and externalization) factors which might be associated with dropout.

Next to this, future research should explore how potential moderators of dropout from physical activity derived from the RCT literature can be translated into effective adherence strategies applicable in “real-world practice”. An additional limitation is the number of identified studies that were excluded for not reporting dropout rates, and therefore were ineligible for pooling in the meta-analysis. This further highlights the importance of adequate reporting in exercise-based RCTs in line with the CONSORT statement (Schulz, Altman, & Moher, 2010) in order to maximise the external validity of trials and facilitate the translation of research to practice.

In conclusion, the current systematic review and meta-analysis demonstrated that one intervention factor (i.e. the type, sports physical activities) and one patient characteristic (i.e. male gender) predicted lower dropout of children and adolescents with ADHD in physical activity intervention trials.

References

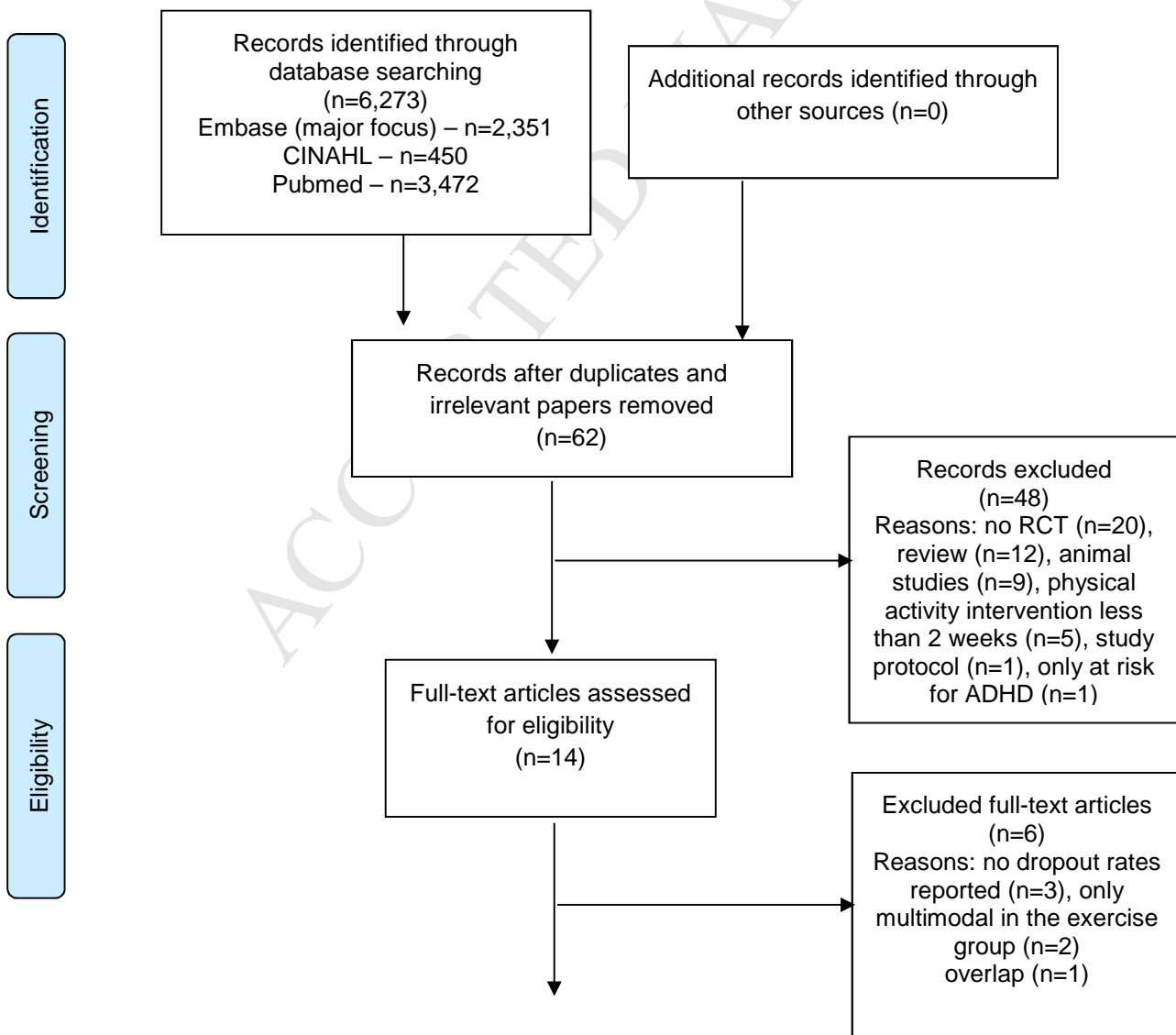
- ACSM's *Guidelines for Exercise Testing and Prescription*. V (8th ed. Vol. 220). (2009). Philadelphia: Lippincott Williams & Wilkins.
- American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*. American Psychiatric Association, Washington, DC.
- Association, A. P. (1994). *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)*: American Psychiatric Association, Washington, DC.
- Begg, C. B., & Mazumdar, M. (1994). Operating characteristics of a rank correlation test for publication bias. *Biometrics*, 1088-1101.
- Boggs, S. R., Eyberg, S. M., Edwards, D. L., Rayfield, A., Jacobs, J., Bagner, D., & Hood, K. K. (2005). Outcomes of parent-child interaction therapy: A comparison of treatment completers and study dropouts one to three years later. *Child & Family Behavior Therapy*, 26, 1-22.
- Bustamante, E. E., Davis, C. L., Frazier, S. L., Rusch, D., Fogg, L. F., Atkins, M. S., & Marquez, D. X. (2016). Randomized Controlled Trial of Exercise for ADHD and Disruptive Behavior Disorders. *Medicine and Science in Sports and Exercise*.
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, 100, 126.
- Chan, E., Fogler, J. M., & Hammerness, P. G. (2016). Treatment of attention-deficit/hyperactivity disorder in adolescents: A Systematic Review. *JAMA*, 315, 1997-2008.
- Chang, Y.-K., Hung, C.-L., Huang, C.-J., Hatfield, B. D., & Hung, T.-M. (2014). Effects of an aquatic exercise program on inhibitory control in children with ADHD: a preliminary study. *Archives of Clinical Neuropsychology*, 29, 217-223.

- Choi, J. W., Han, D. H., Kang, K. D., Jung, H. Y., & Renshaw, P. F. (2015). Aerobic exercise and attention deficit hyperactivity disorder: brain research. *Medicine and Science in Sports and Exercise*, 47, 33-39.
- Cooper, A. A., & Conklin, L. R. (2015). Dropout from individual psychotherapy for major depression: a meta-analysis of randomized clinical trials. *Clinical Psychology Review*, 40, 57-65.
- Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11, 227-268.
- Den Heijer, A. E., Groen, Y., Tucha, L., Fuermaier, A. B., Koerts, J., Lange, K. W., Thome, J., & Tucha, O. (2016). Sweat it out? The effects of physical exercise on cognition and behavior in children and adults with ADHD: a systematic literature review. *Journal of Neural Transmission*, 1-24.
- Duval, S., & Tweedie, R. (2000). Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, 56, 455-463.
- Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *British Medical Journal*, 315, 629-634.
- Gershon, J., & Gershon, J. (2002). A meta-analytic review of gender differences in ADHD. *Journal of Attention Disorders*, 5, 143-154.
- Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal*, 327, 557.
- Hoza, B., Smith, A. L., Shoulberg, E. K., Linnea, K. S., Dorsch, T. E., Blazo, J. A., Alerding, C. M., & McCabe, G. P. (2015). A randomized trial examining the effects of aerobic physical activity on attention-deficit/hyperactivity disorder symptoms in young children. *Journal of Abnormal Child Psychology*, 43, 655-667.
- Janssen, T. W. P., Bink, M., Geladé, K., van Mourik, R., Maras, A., & Oosterlaan, J. (2016). A randomized controlled trial investigating the effects of neurofeedback, methylphenidate, and physical activity on event-related potentials in children with attention-deficit/hyperactivity disorder. *Journal of child and adolescent psychopharmacology*, 26, 344-353.
- Jensen, P. S., & Kenny, D. T. (2004). The effects of yoga on the attention and behavior of boys with attention-deficit/hyperactivity disorder (ADHD). *Journal of attention disorders*, 7, 205-216.

- Kang, K., Choi, J., Kang, S., & Han, D. (2011). Sports therapy for attention, cognitions and sociality. *International Journal of Sports Medicine*, 32, 953-959.
- Lee, S.-K., Lee, C.-M., & Park, J.-H. (2015). Effects of combined exercise on physical fitness and neurotransmitters in children with ADHD: a pilot randomized controlled study. *Journal of Physical Therapy Science*, 27, 2915.
- Meßler, C. F., Holmberg, H.-C., & Sperlich, B. (2016). Multimodal therapy involving high-intensity interval training improves the physical fitness, motor skills, social behavior, and quality of life of boys with ADHD: a randomized controlled study. *Journal of Attention Disorders*, 1087054716636936.
- Organization, W. H. (1993). *The ICD-10 Classification of Mental and Behavioural Disorders-Diagnostic Criteria for Research*. Geneva: World Health Organization.
- Osterberg, L., & Blaschke, T. (2005). Adherence to medication. *New England Journal of Medicine*, 353, 487-497.
- Polanczyk, G. V., Salum, G. A., Sugaya, L. S., Caye, A., & Rohde, L. A. (2015). Annual Research Review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *Journal of Child Psychology and Psychiatry*, 56, 345-365.
- Rogers, M., & Tannock, R. (2013). Are classrooms meeting the basic psychological needs of children with ADHD symptoms? A self-determination theory perspective. *Journal of Attention Disorders*, 20, 1-7.
- Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMC Medicine*, 8, 18.
- Stroup, D. F., Berlin, J. A., Morton, S. C., Olkin, I., Williamson, G. D., Rennie, D., Moher, D., Becker, B. J., Sipe, T. A., & Thacker, S. B. (2000). Meta-analysis of observational studies in epidemiology: a proposal for reporting. *JAMA*, 283, 2008-2012.
- Stubbs, B., Vancampfort, D., Rosenbaum, S., Ward, P. B., Richards, J., Soundy, A., Veronese, N., Solmi, M., & Schuch, F. B. (2016). Dropout from exercise randomized controlled trials among people with depression: A meta-analysis and meta regression. *Journal of Affective Disorders*, 190, 457-466.
- Thapar, A., & Cooper, M. (2016). Attention deficit hyperactivity disorder. *Lancet*, 387, 1240-1250.

- Vancampfort, D., Rosenbaum, S., Schuch, F. B., Ward, P. B., Probst, M., & Stubbs, B. (2016). Prevalence and predictors of treatment dropout from physical activity interventions in schizophrenia: a meta-analysis *General Hospital Psychiatry*, 39, 15-23.
- Yazdani, S. (2013). Factors predicting physical activity among children with special needs. *Preventing Chronic Disease*, 10.

Figure 1
Flow diagram



Included

Studies included in
qualitative synthesis
(n=8)

Table 1

Study, participants and providers' characteristics and dropout rates of the included studies (n=8 involving 9 physical activity arms)

Study	Drop out / invited before start	Exercisers versus controls	Supervision entire period (yes/no) and providers*	Multimodal (yes / no)	Motivational Intervention (yes / no)	Physical activity characteristics	Dropout after start (exercisers vs controls)
Jensen 2004	0/16	8 vs 8 boys with DSM-IV ADHD; 10.6±1.8 years; 37.5% psychiatric co-morbidity	No / yoga instructor	No	No	1 time / week 60 min yoga for 20 weeks at low intensity	2/8 vs 0/8
Kang 2011	8/40	16 boys (8.4±0.9 years; illness duration=2.2 years) vs 16 boys (8.6±1.2 years; illness duration=2.4 years)	Yes / sports psychologist	Yes	Yes	2 times / week 90 min sports therapy for 6 weeks	1/16 vs 3/16
Chang 2014	0/30	10 boys and 4 girls (8.2 years; body mass index=17.7) vs 13 boys (8.8 years; body mass index=16.4)	Yes / instructor with a professional background in water exercises	No	Yes	2 times / week 90 min aquatic sports therapy for 8 weeks at moderate intensity	1/15 vs 2/15
Choi 2015	0/35	13 boys (15.8±1.7 years) vs 16 boys (16.0±1.2 years)	Yes / sports psychologist	Yes	No	3 times / week 45 min sports therapy for 6 weeks at moderate intensity	4/17 vs 1/18
Lee 2015	6/24	6 boys (8.8±1.0 years) vs 6 boys (8.8±1.0 years); no psychiatric co-morbidity	Yes / NA	No	No	3 times / week 60 min structured exercise for 12 weeks at moderate intensity	3/9 vs 3/9
Bustamente 2016	36/71	11 boys and 5 girls (8.7±2.0 years) vs 13 boys and 6 girls (9.4±2.2 years)	Yes / students Kinesiology, Nursing, Public Health, and Pharmacy	No	Yes	5 times / week 90 min sports and play therapy for 10 weeks at moderate intensity	0/18 vs 0/13
Meßler 2016	NA	28 boys (11±1years; body mass index=19.1±3.3)	Yes / sports therapist	Yes	No	3 times / week 60 min sports therapy for 3 weeks at moderate intensity	0/14
			Yes / sports therapist	Yes	No	3 times / week 30 min structured exercise for 3 weeks at high intensity	0/14
Janssen 2016	112/220	37 (9.8±2.0years) vs 75 boys and girls	Yes / NA	No	No	3 times / week 45 min structured exercise for 10 weeks at high intensity	3/37 vs 6/75

NA= not available; *Providers of physical activity/exercise interventions were considered experts when they had at a minimum a bachelor-level degree in physical therapy / physiotherapy, sports therapy, exercise physiology or a similar qualification that included education in exercise prescription and assessment. Also cardiologists and sports physicians were considered as experts.

Table 2

Subgroup analyses of moderators of dropouts in children and adolescents with ADHD

Analysis	Number of comparisons	Meta-analysis				
		Dropout prevalence	95% CI		Between group P-value	I ² P-value
Setting					0.92	26.1 0.21
Inpatients	4	10.6%	3.0%	30.9%		
Outpatients	2	14.3%	4.0%	40.0%		
Community patients	3	10.3%	2.5%	34.0%		
Multi-modal					0.68	26.1 0.21
Yes	5	13.5%	5.7%	28.7%		
No	4	10.2%	3.3%	26.9%		
Physical activity type					<0.001	26.1 0.21
Aerobic exercise	4	16.7%	9.2%	28.5%		
Yoga	1	25.0%	6.3%	62.4%		
Sports	4	5.0%	1.6%	14.3%		
Physical activity frequency					0.41	26.1 0.21
1 time per week	1	25.0%	4.7%	69.1%		
2 times per week	2	6.4%	1.4%	25.6%		
3 times per week	5	14.5%	6.8%	28.3%		
5 times per week	1	2.6%	1.3%	35.0%		
Physical activity intensity					0.79	26.1 0.21
Low	1	25.0%	3.2%	77.3%		
Moderate	4	9.2%	2.6%	24.7%		
High	3	12.9%	3.6%	36.6%		
Additional motivational component					0.10	26.1 0.21
Yes	3	5.4%	9.1%	27.6%		
No	6	16.3%	1.5%	17.5%		
Supervision the entire study period					0.35	26.1 0.21
Yes	8	11.1%	5.6%	20.8%		
No	1	25%	4.5%	70.0%		
Qualified providers					0.14	26.1 0.21
Yes	2	3.3%	4.4%	21.3%		
No	7	14.7%	8.3%	25.0%		

Significant when $P < 0.05$.

Table 3

Meta-regressions of moderators of dropouts in children and adolescents with ADHD

Moderator	Number of comparisons	β	95% CI		P-value	R²
Mean age (years)	9	0.12	-0.14	0.38	0.36	0
Gender (% male)	8	0.05	0.001	0.10	0.045	1.0
Time of the final physical activity session (min)	8	0.009	-0.03	0.04	0.61	0
Duration of the physical activity intervention (weeks)	9	0.10	-0.04	0.24	0.17	0.20

Highlights

- Dropout rates from physical activity interventions in children and adolescents with ADHD are similar to those observed in control conditions.
- Sport activities result in lower drop out than structured aerobic exercise.
- Higher dropouts are observed in males with ADHD.
- Future research should explore physical activity preferences of children and adolescents with ADHD and develop motivational strategies to reduce dropout from physical activity interventions.